Reproduced, with permission, from: Glantz, M. H., and N. S. Orlovsky. 1983. Desertification: A review of the concept. *Desertification Control Bulletin* 9: 15-22.

Desertification:

A review of the concept

Michael H. Glantz
Environmental and Social Impacts Group
*National Center for Atmospheric Research**
Boulder, CO 80307, USA

Nicolai Orlovsky
Desert Research Institute
Turkmen Academy of Sciences
Ashkhabad, Turkmen SSR, USSR

The following article will appear in the Encyclopedia of Climatology, J.E. Oliver and R. Fairbridge, eds., Hutchinson Ross Publishing Company, 1984

The National Center for Atmospheric Research is operated by the University Corporation for Atmospheric Research and is sponsored by the National Science Foundation.

The phenomenon known as desertification has received widespread attention recently, as witness the creation of the United Nations Conference on Desertification in Nairobi in 1977, mainly as a result of the impact of extended drought in the West African Sahel in the early 1970s. That drought caused loss of human lives and livestock and widespread environmental deterioration. Although a number of recent articles, papers and reports from many countries begin with comments on the role of the Sahelian drought in the growing interest in the desertification issue (e.g. Glantz, 1977; UN Secretariat, 1977; Quintanilla, 1981; Zonn, 1981), that drought was neither the first manifestation of the desertification phenomenon nor the only reason for scientific interest in it. In fact, A. Aubreville, a French scientist, popularized the term desertification in his report as long ago as 1949 (Aubreville, 1949), and others (e.g. Le Houerou, 1962) have discussed the phenomenon since the late 1950s.

The 1977 Nairobi Conference did serve to draw attention to the phenomenon (UN Secretariat, 1977). It described desertification as:

"...the diminution or destruction of the biological potential of the land, (which) can lead ultimately to desert-like conditions. It is an aspect of the widespread deterioration of ecosystems, and has diminished or destroyed the biological potential, i.e. plant and animal production, for multiple use purposes at a time when increased productivity is needed to support growing populations in quest of development. Important factors in contemporary society--the struggle for development and the effort to increase food production, and to adapt and apply modern technologies, set against a background of population growth and demographic changes--interlock in a network of cause and effect. Progress in development, planned populations growth and

improvements in all types of biological production and relevant technologies must therefore be integrated. The deterioration of productive ecosystems is an obvious and serious threat to human progress. In general, the quest for ever greater productivity has intensified exploitation and has carried disturbance by man into less productive and more fragile lands. Overexploitation gives rise to degradation of vegetation, soil and water, the three elements which serve as the natural foundation for human existence. In exceptionally fragile ecosystems, such as those on the desert margins, the loss of biological productivity through the degradation of plant, animal, soil and water resources can easily become irreversible, and permanently reduce their capacity to support human life. Desertification is a self-accelerating process, feeding on itself, and as it advances, rehabilitation costs rise exponentially. Action to combat desertification is required urgently before the costs of rehabilitation rise beyond practical possibility or before the opportunity to act is lost forever (UN Conference to Combat Desertification, 1978)"

The conference also served to bring together representatives of many countries whose landscapes had been directly or indirectly affected by desertification. The usefulness of the conference varied from country to country. For some countries, such as the People's Republic of China, it served to direct the attention of national policy-makers to arid lands research and to elevate such research to the status of a national priority. The Soviet Union's State Committee for Science and Technology (GKNT) established, with UNEP, international training courses on various aspects of desertification and on ways to identify and combat it (Zonn, 1981). In the United States and other countries the attention of national policy-makers was directed toward this form of environmental degradation and a Plan of Action was drawn up to assess desertification in a national context (Sabadell *et al.*, 1982).

Desertification is acknowledged to be a complex phenomenon requiring the expertise of researchers in such disciplines as climatology, soil science, meteorology, hydrology, range science, agronomy, veterinary medicine, as well as geography, political science, economics and anthropology. It has been defined in many different ways by researchers in these and other disciplines, as well as from many national and bureaucratic (institutional) perspectives, each emphasizing different aspects of the phenomenon.

Desertification is of particular interest to climatologists in their attempts to understand climate variation and change on both short and long time scales (e.g. Hare, 1976). With increasing pressure on governmental decision-makers to allow populations to move into the climatically marginal areas, the implications of natural variations in climate have become even more important in decisions relating to the use by society of its land in these desertification-prone regions. One can easily assert that there will always be climatic deserts. However, man-induced extensions of these deserts or the creation of desert-like conditions in areas where they had not existed can and must be avoided. The climatological communities at both the national and international levels (through, for example, the World Meteorological Organization's Climate Programme and UNEP's World Climate Impacts Programme) have, in general, made the identification of the climatological and meteorological aspects of desertification one of their most important priorities.

A review of the desertification literature shows a great diversity (and confusion) among definitions (e.g. Carder, 1981). This mix of definitions (meanings attributed to the concept) leads to miscommunication among researchers, among policy-makers, and most important, *between* researchers and policy-makers (see IGU, 1975, passim). An analysis of the definitions of desertification could prove useful in developing an improved understanding of the phenomenon, of how it is viewed from different disciplines and countries (and bureaucratic units), and of whether progress in combating it has in fact been as slow as many observers suggest (e.g. UN General Assembly, 1981).

In the following sections we use these definitions as the basis for discussion, as they are often what is seen and used by decision-makers. In the last section it is argued that the concept of desertification also applies to higher-rainfall regions than those cited by contemporary researchers.

Desertification: What is it?

Some researchers consider desertification to be *a process* of change, while others view it as the *end result* of a process of change. This distinction underlies one of the main disagreements about what constitutes desertification. Desertification-as-process has generally been viewed as a series of incremental (sometimes step-wise) changes in biological productivity in arid, semi-arid, and subhumid ecosystems. It can encompass such changes as a decline in yield of the same crop or, more drastically, the replacement of one vegetative species by another maybe equally productive or equally useful, or even a decrease in the density of the existing vegetative cover. Desertification-as-event is the creation of desert-like conditions (where perhaps none had existed in the recent past) as the end result of a process of change. To many, it is difficult to accept incremental changes as a manifestation of desertification.

In fact, these two views represent different aspects of a broader concept of desertification. Thus, seemingly different statements such as "the creation of desert-like conditions in areas once green", "encroachment of desert-like conditions", "the intensification of desert-like conditions", as well as less drastic projections like "changes in soils and in climate" or "the land becoming less fit for range and crops", can be encompassed by the concept of desertification.

Form of change

Within the dozens of existing definitions of desertification, many words are used to describe the phenomenon, some of which complement each other while others appear to be contradictory. A point on which they all agree however, is that desertification is viewed as an adverse environmental process. The negative descriptors used in these definitions of desertification include: deterioration of ecosystems (e.g. Reining, 1981), degradation of various forms of vegetation (e.g. Le Houerou, 1975), destruction of biological potential (e.g. UNCOD, 1978), diminution of biological potential (ibid.), decay of a productive ecosystem (e.g. Hare, 1977), reduction of productivity (e.g. Kassas, 1977), decrease of biological productivity (e.g. Kovda, 1980), alteration in the biomass (e.g. UN Secretariat, 1977), intensification of desert conditions (e.g. Meckelein, 1980; WHO, 1980), and impoverishment of ecosystems (e.g. Dregne, 1976).

Each of these terms suggests change from a favoured or preferred state (with respect to quality, societal value, or ecological stability) to a less favoured one and each has been used to describe the condition of vegetation, or moisture availability, or soils, or atmospheric phenomena, depending on the particular definition. Other descriptors used in these definitions connote a movement or a transfer of the characteristics of a desert landscape into an area where such characteristics had not existed; extension, encroachment, acceleration, spread, and transformation. If one combined each of these negative and transfer descriptors with all the other factors cited in the existing definitions, desertification would encompass most kinds of environmental changes related to biological productivity (see Rozanov, 1981).

What is changed

Different definitions focus on changes in soil (e.g. salinization), or vegetation (e.g. reduced density of biomass), or water (e.g. waterlogging), or air (e.g. increased albedo). Most of them, regardless of primary emphasis, also describe changes in biological productivity, with comments related to the type, density, and value of vegetation.

Type-of-vegetation comments centre on changes from desired (or accepted) species to less desired (or less accepted) ones. Such comments cover a reduction in the proportion of preferred species having an economic or societal value, the lowering of yields of an existing preferred species, or a major ecological change such as species replacement.

Changes in the density of the vegetative cover constitute an important factor acknowledged by many authors in their definitions of desertification. As density decreases, for example, the risks of wind erosion, water erosion and the adverse effect of increased solar radiation on bare soils are increased dramatically. Surface albedo (reflectivity), also enhanced by a reduction in the vegetative cover, is a major contributor to desertification processes.

With respect to the value of vegetation, a few researchers have explicitly referred to "lower useful productivity" (Johnson, 1977), "reduced productivity of desirable plants" (Dregne, 1976), "sustained decline in the yield of useful crops" (UN Secretariat, 1977), and "loss of primary species" (Rapp *et al.*, 1976). However, the concern with the value of vegetation in desertification processes is not shared by all. Some researchers have dismissed the value concern, by suggesting that any type of vegetation that holds the soil in place is of value in the fight against desertification, whether or not it has an economic value.

As a final comment on what desertification is, it is important to note that disciplinary and institutional biases may appear in any given definition of the phenomenon. For example, a meteorological bias might require for the use of the term "desertification" that a change take place in the meteorological parameters of a given region, so that they become similar to those for a desert region (e.g. high evaporation rates, aridity, increased rainfall intensity, and so on). As another example, Meckelein (1976; cited in Kharin and Petrov, 1977) alluded to the disciplinary bases for desertification when he wrote that desertification could be characterized by the following components: *climate*: increasing aridity (diminishing water supply); *hydrological processes*: runoff becoming more irregular; *morphodynamic processes*: intensification of distinct geomorphological processes (accelerated soil erosion by wind and water); *soil dynamics*: desiccation of soils and accumulation of salt; *vegetation dynamics*: decline of vegetation.

Location of change

There is no agreement on where desertification can take place. Many researchers identify arid, semi-arid, and sometimes subhumid regions as the areas in which desertification can occur or where the risks of desertification are highest. Others imply that the areas prone to desertification might not be restricted to arid, semi-arid, or subhumid regions, by using such descriptive words as extension, encroachment, and spread of desert characteristics into non-desert regions. Still others (e.g. Mabbutt and Wilson, 1980, p.11) refer to the intensification of desert-like areas. Many oppose this view, however, contending that desert-like conditions cannot be created in a desert. They assert that desertification can only occur along the desert fringes. According to Le Houerou, "desertification" can occur only in the 50-300 mm isohyet zone.

Reversibility

Few definitions explicitly refer to whether desertification is permanent. Le Houerou (1975), for example, explained briefly the conditions under which desertification might be reversible. Others have implied reversibility with reference to the higher costs of rehabilitation of desertified areas as opposed to prevention. For example, Adams suggested that the "reversibility of desertification was a function of technology and the cost of rejuvenating an area... Irreversibility should refer to a situation in which the costs of reclamation were greater than the return from a known form of land use" (IGU, 1975, p.133). Still others implied irreversibility by referring to the *end result* of desertification as the creation of desert-like conditions.

Two additional important considerations relating to the permanence of desertification are (a) when desertification (as a process or event) might be reversed (i...e the "time" factor), and (b) under what conditions (i.e. the "how" factor).

With respect to the time factor, desertification may be considered by some observers to be irreversible during

a season or a few seasons but may be reversible on the scale of decades, or if not decades, perhaps centuries. Peel "saw great danger in the concept of irreversibility because it has no time limitations whatever" (IGU, 1975, p.138). One author has drawn a distinction between temporary and permanent desertification (WMO Secretariat, 1982). Is it possible to distinguish between temporary desertification and, for example, seasonal environmental changes? Some have addressed this question by defining desertification as a sustained (as opposed to temporary) decline in biological productivity (e.g. Sabadell *et al.*, 1982; UN Secretariat, 1977). Le Houerou, commenting on "what is temporary?", noted that while temporary fluctuations may be interspersed with more favourable conditions, such a condition of successive crises does involve a progressively deteriorating situation, possibly past a threshhold of irreversibility" (IGU, 1975, p.27).

With respect to how desertification might be reversed, the reversal might occur naturally, once the contributing causes have been removed. Otherwise, human intervention might be required (e.g. Kassas, 1977) if there is a desire on the part of decision-makers to reverse it in less time than might be required to do so naturally. Chinese scientists, for example, have recently suggested a programme for reversing desertification in the People's Republic of China (Zhenda and Shu, 1981).

Desertification: Why does it occur?

Some researchers consider climate to be the major contributor to desertification processes, with human factors playing a relatively minor supporting role. Other researchers reverse the significance of these two factors. For example, Le Houerou (1959) concluded that "on its edges the Sahara is mainly made by man, climate being only a supporting factor" (quoted in Rapp, 1974, p.32). A third group blames climate and man more or less equally. For example, Grove (1973) has noted that "desertification or desert encroachment can result from a change in climate or from human action and it is often difficult to distinguish between the two." Each of these views can be shown to be valid, at least at the local level, and on a case-by-case basis. This suggests that there is a region-specific bias to perceptions about desertification, one that spills over to the definitions. Debates about causes of desertification occupy a large part of the desertificaton literature and need only be summarized here.[*1*]

Climate

References to climate in these definitions relate either to climate variability, climate change, or drought. *Climate variability* a (term that is usually itself undefined in these definitions) seems to refer to the natural fluctuations that appear in the statistics representing the state of the atmosphere for a designated period of time, usually of the order of months to decades. Fluctuations may occur in any or all of the atmospheric variables (such as precipitation, temperature, wind speed and direction, evaporation, etc.). A result of those fluctuations may be the alteration of an ecosystem, and this could eventually affect societal activities that have been developed to exploit the productivity of that ecosystem.

It is important to note that during the annual dry season the characteristics of the atmosphere in an arid or semiarid area are like that of a desert-like region (low precipitation, high evaporation, high solar radiation, etc.) and if improper use of the land occurs during this period, degradation results (Aubreville, 1949). Thus, short-term fluctuations in climatic factors as well as seasonal dry periods, when combined with improper land-use practices, can give the appearance of the impact of a climate change when none may have occurred at all.

Climate change refers to the view that the statistics that represent the average state of the weather for a relatively longer period of time are changing, and that desertification is primarily a result of such natural shifts in climate regimes. It has been suggested, for example, that there has been a trend towards increasing aridity in the West African Sahel, a natural desiccation of the region that man can do nothing to stop. Usually cited as evidence for longer term climate changes in that area in the past are fossil dune fields near the West African

coast far from the active dunes close to the desert. The debate over long-term climate change in the West African Sahel continues.

Drought episodes have also been cited as a major cause of desertification, since during such extended dry spells desertification becomes relatively more severe, widespread, and visible, and its rate of occurrence increases sharply. As the probability of droughts increases as one moves from the humid to the more arid regions, so, too, does the proneness to desertification. Land forms, soils, and vegetation are often transformed during such extended drought periods.

Human activities

Cultivation, herding and woodgathering practices, as well as the use of technology, have all been cited in the definitions as major causes of, and contributors to, the desertification process in arid, semi-arid and subhumid areas. *Cultivation practices* that can lead to desertification include land-clearing practices, cultivation of marginal climatic regions, cultivation of poor soils, and inappropriate cultivation tactics such as reduced fallow time, improper tillage, drainage, and water use. For example, areas that might support agriculture on a shortterm basis may be unable to do so on a long-term sustained basis. Even areas that are considered suitable for cultivation may become degraded if they are managed in a way that is inappropriate to the ecological and climatic setting.

Rangeland use that can lead to desertification includes excessively large herds for existing range conditions (leading to overgrazing and trampling) and herd concentration around human settlements and watering points. Government policies towards their pastoral populations can also indirectly lead to desertification by, for example, not pursuing policies that encourage herders to cull their herds, by putting a floor on grain prices and a ceiling on prices that pastoralists might receive for their livestock, and so forth.

Gathering fuelwood by itself or in combination with overgrazing or inappropriate cultivation practices creates conditions that expose the land to existing "otherwise benign" meteorological factors (such as wind, evaporation, precipitation runoff, solar radiation on bare soil, etc.), thereby contributing to desertification.

The *use of technology* in arid, semi-arid and subhumid environments is the result of the policy-makers' desire for economic development. Thus, deep wells, irrigation and cash-crop schemes, even the reduction of livestock diseases such as sleeping sickness (trypanosomiasis), each in its own way, can increase the risk of desertification processes in an area. It has been shown that desertification can result from road building, industrial construction, geological surveys, ore mining, settlement construction, irrigation facilities, and motor transport (Rozanov, 1977).

In sum, most researchers accept the fact that both factors are involved in the desertification process, with a few observers noting that the two factors are so entwined that to separate them into primary and secondary contributors would be a fruitless endeavour.

Return to Aubreville

Aubreville discussed desertification at great length in his 1949 report entitled *Climats, Forêts et Désertification*. His work, when compared to the scores of contemporary definitions, raises the issue about *where* desertification can take place. Most of these contemporary definitions relate desertification to what, broadly speaking, might be viewed as the desert fringes. For example, a UNEP report identified types of deserts as rainless, runoff, rainfall and man-made, with man-made deserts defined as "parts of the semi-arid steppe country (rainfall 200-350 mm/yr) that have been transformed into deserts due to overexploitation (desertification) (1975, p. 1) . Aubreville, however, explicitly referred to the tropical forest of Africa delimited

by the 700 to 1,500 mm precipitation isohyets, noting that: "These are real deserts that are being born today, under our eyes, in the regions where the annual rainfall is from 700 mm to 1,500 mm (Ce sont de vrais déserts que naissent aujourd'hui, sous nos yeux, dans des pays où il tombe cependant annuellement de 700 à plus de 1,500 mm de pluies) (p. 332). Thus the view of desertification given by Aubreville, who has been considered by many the father of the concept, would have no place in desertification studies today because it fails to meet the criteria identified in most contemporary definitions.

Aubreville viewed desertification primarily as a process but also referred to it as an event (the end state of a process of degradation). He described how forested regions were transformed into savanna and savanna into desert-like regions. One of Aubreville's central concerns was the rate of destruction, resulting from human activities, of Africa's tropical forests. He noted that cultivation, deforestation, and erosion were so entwined as to lead to the destruction of the vegetative cover and soils in the forested regions of tropical Africa where "the desert always threatens, more or less obviously, but is always present in the embryonic state during the dry and hot season" (le désert menace toujours, plus ou moins évidemment, mais il est toujours present, à l'état embryonnaire, dans la saison sèche et chaude). Savanna would result. Continued disregard for the fragility of the savanna would result in the creation of desert-like conditions.

Aubreville's research findings are directly relevant to contemporary efforts to identify, understand, and combat desertification processes. The reincorporation of his research into the desertification discussions is not a call to discard other definitions. It is a call to broaden our thinking about what constitutes desertification as a process and where that process might occur. If desertification can be identified by some of its component subprocesses, such as soil erosion, deforestation, overgrazing, or cultivation in marginal areas (determined, for example, by soil characteristics or by the amount of rainfall), then there is a great deal of research activity under way that relates directly as well as indirectly to desertification, without explicitly having desertification in its title (e.g. Riquer, 1982).

Finally, a broader conception of desertification would shed a different light on progress in the understanding and combating of the phenomenon. There is much research under way on soil erosion, range management, deforestation, increasing biological productivity in arid lands, and so forth. These research activities contribute to the fight against desertification processes, regardless of whether or not the term appears in the title of the programme or project. Viewed in this broader context, it can be shown that there are many activities that contribute to an increase in our knowledge and understanding of the phenomenon known as desertification. Only in this broader conceptualization can we develop a more accurate assessment of how nations are faring in their war against desertification.

This paper is based on a review of more than one hundred definitions of desertification taken from the literature. References cited in this paper include only a part of these definitions.

---

1 In a recent book on drylands, the authors noted in a section on desert expansion and its causes that "There are two schools of thought about the mysteries of the expanding deserts: either the changes are due entirely to climate variation, or man is the cause, independently of the climate or in association with its variations." These authors noted that in the absence of accurate paleoclimatological data. "it must be assumed that man is the most common cause, sometimes in combination with climatic variations but generally on his own" (Adam *et al., Drylands.* 1979, pp.3-4).

REFERENCES

Adams, R. *et al. Dry Lands: Man and Plants.* New York, St. Martins Press. pp. 3-5.

Aubreville, A. (1949). *Climats, Forêts et Désertification de l'Afrique Tropicale.* Paris, Société d'Editions Géographiques, Maritimes et Coloniales.

Carder (1981). *Search* (12(7): 218-221.

Dregne, H.E. (1976). Desertification: Symptoms of a crisis. In *Desertification, Process, Problems, Perspectives.* University of Arizona Press.

Glantz, M.H. (ed.) (1977). *Desertification: Environmental Degradatian in and around Arid Lands.* Boulder, Westview Press.

Grove, A.T. (1973). Desertification in the African Environment. In *Drought in Africa: Report of the 1973 Symposium* (D. Dalby and R.J. Harrison Church, eds.) London, School of Oriental and African Studies.

Hare, K. (1976). *Climate and Desertification.* Working Group on Climate and Human Response, Institute for Environmental Studies, University of Toronto.

_____ (1977). Connections between climate and desertification, *Environmental Conservation* 4(2): 82.

IGU (International Geophysical Union) Working Group on Desertification (1975). Proceedings of the IGU Meeting on Desertification, Cambridge 22-26 September 1975.

Johnson, D.L. (1977). The human dimensions of desertification. *Economic Geography* 53(4): 317-18.

Kassas, M. (1977). Arid and semi-arid lands: Problems and prospects. *Agro-Ecosystems* 3:186.

Kharin, N.G. and Petro M.P. (1977). *Glossary of Terms on Natural Conditions and Desert Development.* Materials for the UN Conference on Desertification, Moscow.

Kovda, V. (1980). *Land Aridization and Drought Control.* Boulder Westview Press.

Le Houerou, H.N. (1962). Les pâturages naturels de la Tunisie aride et désertique. Paris, Inst. Sces. Econ. Appl. Tunis.

_____ (1975). The nature and causes of desertization. In Proceedings of the IGU Meeting on Desertification, Cambridge, 22-26 September 1975. (Also reprinted in *Desertification* (M.H. Glantz, ed.) Westview Press, 1977).

Mabbutt, J.A. and A.E. Wilson (eds.) (1980). *Social and Environmental Aspects of Desertification.* Tokyo, UN University.

Meckelein, W. (1980) . The Problem of desertification within deserts. In *Desertification in Extremely Arid Environments,* IGU Working Group on Desertification in and around Arid Lands, 24th International Geographical Congress, Tokyo.

Quintanilla, E.G. (1981) . Regional aspects of desertification in Peru. In *Combating Desertification through Integrated Development,* UNEP/UNEPCOM International Scientific Symposium, Abstract of Papers, Tashkent, USSR, 114-115.

Rapp, A. (1974) . *A Review of Desertization in Africa: Water, Vegetation and Man.* Stockholm, Secretariat for International Ecology.

Rapp, A. H.N. Le Houerou and B. Lundholm (eds.) (1976). *Can Desert Encroachment Be Stopped? A Study with Emphasis on Africa.* Stockholm, Swedish Natural Science Research Council.

Reining, Priscilla (compiler) (1978). *A Handoook on Desertification Indicators* (based on the Science Associations' Nairobi Seminar on Desertification, Washington, American Association for the Advancement of Science.

Riquer, J. (1982). A world assessment of soil degradation. *Nature and Resources* 18(2), 18-2.

Rozanov, B.G. (1977). Degradation of arid lands in the world and international cooperation in desertification control. *Pchvovedenie* 8: 5-11.

_____ (1981). Principles of desertification diagnostics and assessment. In *Combating Desertification through Integrated Development*. UNEP/UNEPCOM International Scientific Symposium, Abstract of Papers, Tashkent, USSR, 24-26.

Sabadell, J. *et al*. (1982). *Desertification in the United States: Status and Issues.* Final report for the Bureau of Land Management and Department of the Interior, Washington.

UN Conference on Desertification (1978). *Round-up, Plan of Action and Resolutions.* New York, United Nations.

UN General Assembly (1981). Development and International Economic Cooperation: Environment. Study on financing the Plan of Action to Combat Desertification, report of the Secretary General. Report A/36/141. New York, United Nations.

UN Secretariat of the Conference on Desertification (1977). Desertification: An overview, *In Desertification: Its Causes and Consequences.* New York, Pergamon Press.

UNEP (1975). *Overviews in the Priority Subject Area Land, Water and Desertification.* Nairobi, UNEP.

World Meteorological Organization (1980). Expert Meeting on Meteorological Aspects of Desertificatiion, December 1980. Report of the Meeting, point 2.4. Geneva, WMO.

Zhu, Zhenda and Liu Shu (1981). Desertification control in northern China. *Desertification Control* 5:13-19.

Zonn, I.S. (ed.) (1981). *USSR/UNEP Projects to Combat Desertification.* Moscow Centre of International Projects GKNT, 33.